Form ESA-B4. Summary Report for ESA-110-2
Public Report - Final

Company	ArcelorMittal USA Inc.	ESA Dates	July 10 - 12, 2007
Plant	Riverdale, IL	ESA Type	Compressed Air
Product	Hot roll sheet steel	ESA Specialist	Mr. Michael Kostrzewa, P.E.

Brief Narrative Summary Report for the Energy Savings Assessment:

Introduction:
This facility manufactures hot-rolled sheet steel products. The plant operates a ladle metallurgy facility, a continuous thin slab caster and a hot strip mill and is capable of producing 1,200,000 tons of raw steel annually in its basic oxygen furnaces. Molten iron is supplied by rail from blast furnaces at the Indiana Harbor and Burns Harbor facilities. ArcelorMittal Riverdale is the former Acme Steel Company and has stood on this site since approximately 1910. The compact strip mill was finished in 1996.

The manufacturing process is separated into two plants: a basic oxygen furnace (BOF) and a compact strip production (CSP) facility. A basic oxygen furnace is where the molten iron from the blast furnaces is changed into liquid steel. The process is known as 'basic' due to the 'pH' of the refractories - calcium oxide and magnesium oxide - that line the vessel. The molten iron is poured into the furnace in batches on top of scrap and other raw materials and additives. Fluxes are charged into the mix using a dense-phase pneumatic conveyance system – one of the largest periodic compressed air uses in the plant. Oxygen is blown into the furnace through a water-cooled oxygen lance. This oxidizes carbon and the other unwanted elements in the hot metal. Carbon is oxidized to carbon monoxide gas, which passes through a water spray in a cooling tower that uses compressed air to atomize the spray water. The air use increases during blowing, but also consumes a steady 200 cfm of compressed air at other times. The steel is tapped from the furnace when it is at the correct temperature and composition. The furnace is tilted and the molten metal is run out via the taphole into a ladle. The ladle is loaded onto a rail car and transported to the CSP facility.

The CSP consists of a ladle metallurgy facility (LMF), a caster, a long tunnel furnace, and a hot strip mill. The LMF's function is to refine the steel chemistry and maintain temperature. The LMF also acts as a buffer or holding area between the melt shop and caster. Ladle arrival at the caster must be closely synchronized with the process. The LMF operator takes a sample of the steel, and based on the sample results, adds a controlled amount of lime and alloys to the steel in the ladle. Lime reacts with impurities, forming slag that floats on top of the metal. As needed, alloys are added to the steel. Coke injectors that use compressed air add coke to the LMF batch. This is another significant and periodic use of compressed air. Each of the two injector systems use about 250 cfm at 90 psi for about 3-6 minutes per cycle. When the chemistry and temperature at the LMF are within specifications, the ladle is poured into the tundish of the continuous caster. The slab emerges from the bottom of the caster and is immediately cooled through an air mist system that uses compressed air to atomize water with an engineered nozzle. Compressed air for this process is supplied by a separate system not considered in this ESA. The slab proceeds through the tunnel furnace to the hot strip mill. Plant air is used for an air wipe that removes water from the surface prior to entering the tunnel furnace. Compressed air consumption in the strip mill includes an air cylinder on the furnace door, purge air for a pyrometer and metal detector at the tunnel exit, air cylinders on an air-operated banding machine, and for cooling the cradle rolling cooler on the same banding machine. Miscellaneous compressed air uses include baghouse bag cleaning, air to keep photo eyes clear and cool, agitation and air pumps in sump tanks, and agitation of the sand filters in the waste water treatment facility.

Two compressed air systems were considered in this ESA: the four-compressor system that serves the BOF process facility, and the four-compressor system that serves the CSP facility. A separate air mist system was not considered. The BOF system consists of three Sullair 350 hp two-stage lubricant-injected rotary screw compressors and an older Sullair 350 hp single-stage lubricant-injected rotary screw compressor. This system includes an externally heated blower purge desiccant dryer capable of handling two compressors, filters on both sides of the dryer, a 1,042 gallon receiver in the compressor room, and a secondary receiver of about 3,050 gallons located in the BOF building. At the time of the ESA, one of the two-stage compressors was down for repairs, so the backup single-stage compressor was operating. Typically, the three two-stage compressors operate to serve the plant loads, with one or two base load compressors and one trim compressor. These three compressors are also linked together with a communications module for sequencing. The system supplies 110-120 psig air to the BOF process.

The CSP system consists of four Ingersoll-Rand single-stage lubricant-injected rotary screw compressors: one 200 hp, one 250 hp, and two 350 hp units. The system typically operates on the 250 hp compressor and one of the 350 hp compressors that is equipped with an external variable frequency drive (VFD). This system includes an Ingersoll-Rand externally heated blower purge desiccant dryer capable of handling two or three of the compressors that are located in a compressor room near the LMF, and a separate externally heated blower purge desiccant dryer that serves the 250 hp compressor located towards the west side on the CSP near the hot strip mill. Filters are located on both sides of each dryer. A 1,069 gallon receiver is located in the west compressor room, another 668 gallon receiver is located in the east compressor room, and a 2,966 gallon secondary receiver is located outdoors near the baghouse for the LMF. Given the significant distance between the two compressor rooms, there is no communications between the compressors for sequencing. The system supplies 93 - 109 psig air to the CSP facility.

Objective of ESA:
The objective of the ESA was to identify potential energy savings opportunities related to the compressed air system while introducing facility personnel to the U.S. Department of Energy's AIRMaster+ and the Compressed Air Challenge's LogTool software tools.

Focus of Assessment:
The primary focus of the ESA was operation of the compressor performance and sequencing to meet the plant loads. Additionally, the production processes and equipment were examined to observe the compressed air end uses and understand the equipment needs in the plant. Recording dataloggers were used to determine: 1) the current draw on the three operating compressors located in plant compressor room A (Nos. 1, 3, and 4); 2) the pressure profile at the primary receiver in the plant compressor room A; 3) the current draw on the VSD compressor and the 250 hp compressor in plant area B; and 4) the pressure profile at the stand pipe in the west compressor room in plant area B. The loggers were installed on the first day of the ESA and gathered about 48 hours worth of data, the exception being the pressure logger in the plant compressor room A that malfunctioned during the first day but was reset to gather data for the second and third days of the ESA.

Approach for ESA:

1. A kickoff meeting was held with the Site Lead and the Energy Expert to review the objectives of the ESA and review the ESA procedures.
2. The Energy Expert and a Plant Electrician discussed the datalogging capabilities and decided upon locations to place recording dataloggers in the BOF facility, and the dataloggers were installed on the system.
3. A second meeting was held with about 15 more plant personnel, electricians, engineers, and others with responsibility or interest in the compressed air system. Plant and corporate personnel also discussed their expectations for the ESA and reviewed the compressed air system at the plant.
4. The Energy Expert and a Plant Electrician discussed the datalogging capabilities and decided upon locations to place recording dataloggers in the CSP facility, and the dataloggers were installed on the system.
5. A tour of the CSP compressor rooms and the production operations was conducted by CSP staff and the Energy Expert. During this tour, nameplate information and rated performance information on the compressors was collected and some of the compressed air end uses were observed.
6. A tour of the BOF compressor room was conducted to collect nameplate information and rated performance information on the BOF compressors.
7. A training session was conducted for some of the BOF plant staff to provide background information on the ESA program and introduce the concepts used in the AIRMaster+ and LogTool software tools.
8. The compressor performance data from the first 24 hours of data was used to develop a preliminary compressor/system model in LogTool and the AIRMaster+ model.
9. The AIRMaster+ and LogTool models were used to quantify potential opportunities.
10. A tour of the BOF production operations was conducted by BOF staff and the Energy Expert.
11. A debrief presentation detailing the process and the opportunities developed during the ESA was presented to the Site Lead and plant support staff.

General Observations of Potential Opportunities:

From information supplied by the plant, this facility used about 655,131 MMBtu/yr (191,951,733 kWh) of electricity and about 957,000 MMBtu/yr of gas in 2006. The nominal impact costs used were $0.0600/kWh for electric energy and $8.00/MMBtu for natural gas, representing typical 2007 Chicago regional utility prices for large industrial consumers.

Compressor current and pressure data collected from a two-day period from about midday July 10, 2007 through the afternoon of July 12, 2007 was used to develop a baseline AIRMaster+ model of the compressed air system at this plant. The table below summarizes the results of this model:

AIRMaster+ Baseline Model Results – BOF

	Model	Manufacturer	Compressor Type	Compressor	Control Type	Rated Full Load Pressure *psig*	Rated Capacity *acfm*
			BOF				
Compressor #1	350 hp	Sullair Corporation	Two stage lubricant-injected rotary screw	3	Variable displacement with unloading	125	1,733
Compressor #2	350 hp	Sullair Corporation	Two stage lubricant-injected rotary screw	OFF	Variable displacement with unloading	125	1,733
Compressor #3	350 hp	Sullair Corporation	Two stage lubricant-injected rotary screw	1	Variable displacement with unloading	125	1,733
Compressor #4 (Spare)	350 hp	Sullair Corporation	Single stage lubricant-injected rotary screw	2	Variable displacement with unloading	100	1,691
TOTALS	**1,400 hp**					**475**	**6,890**
	Model	Average Airflow *acfm*	Average Airflow *% System*	Peak Demand *kW*	Load Factor *%*	Annual Energy Consmpt'n *kWh/yr*	Annual Energy Cost *per year*
Compressor #1	350 hp	201	11.5%	160.2	25.3%	599,487	$36,035
Compressor #2	350 hp	0	0.0%	0.0	0.0%	-	$0
Compressor #3	350 hp	658	37.6%	180.0	59.6%	1,414,445	$85,022
Compressor #4	350 hp	347	20.7%	164.5	37.8%	993,998	$59,749
TOTALS		**1,206**	**13.6%**	**499.9**	**30.9%**	**3,007,930**	**$180,806**

AIRMaster+ Baseline Model Results – CSP

	Model	Manufacturer	Compressor Type	Compressor	Control Type	Rated Full Load Pressure *psig*	Rated Capacity *acfm*
CSP							
Compressor #1	200 hp	I-R	Single stage lubricant-injected rotary screw	OFF	Variable displacement with unloading	125	892
Compressor #2	350 hp	I-R	Single stage lubricant-injected rotary screw	OFF	Variable displacement with unloading	125	1,740
Compressor #3	350 hp	I-R	Single stage lubricant-injected rotary screw	1	Variable displacement with VSD	125	1,740
Compressor #4	250 hp	I-R	Single stage lubricant-injected rotary screw	2	Inlet modulation without unloading	100	1,249
TOTALS	**1,150 hp**						**5,621**
	Model	Average Airflow *acfm*	Average Airflow *% System*	Peak Demand *kW*	Load Factor *%*	Annual Energy Consmpt'n *kWh/yr*	Annual Energy Cost *per year*
Compressor #1	200 hp	0	0.0%	0.0	0.0%	-	$0
Compressor #2	350 hp	0	0.0%	0.0	0.0%	-	$0
Compressor #3	350 hp	489	27.6%	227.1	66.9%	1,437,318	$86,397
Compressor #4	250 hp	1,278	100.0%	203.5	110.9%	1,652,028	$99,303
TOTALS		**1,767**	**30.8%**	**428.4**	**44.5%**	**3,089,346**	**$185,700**

AIRMaster+ Baseline Model Results – Both Compressor Systems

	Rated Capacity *acfm*	Power Rating *hp*	Total Operating Hours *per yr*	Average Airflow *acfm*	Average Airflow *% System*	Peak Demand *kW*	Load Factor *%*	Annual Energy Consmpt'n *kWh/yr*	Annual Energy Cost *per year*
TOTALS	**12,511**	**2,550**	**8,304**	**2,973**	**23.8%**	**928.3**	**31.8%**	**6,097,277**	**$356,490**

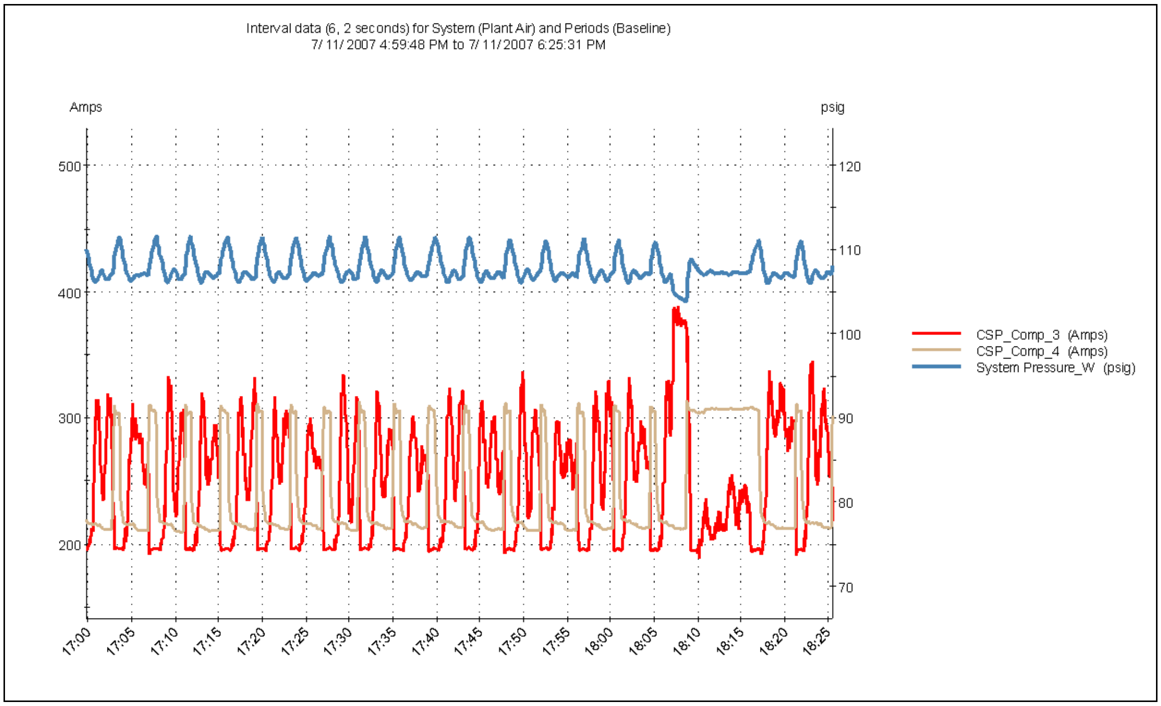
The two compressed air systems combined use about 9% of the total electric energy consumption (kWh) at this plant.

The following Near Term, Medium Term, and Long Term Opportunities were identified during the ESA:

1. Reduce Air Leaks (Near Term Opportunity)
   Air leaks are considered to be significant loads at just about any plant. At most plants the typical leak load is 20-40% of the total system airflow. At this plant, the total combined air flow is about 2,973 cfm, so 20% leakage would be about 600 cfm. The system was modeled in AIRMaster+ using a current air leak load of 250 cfm shop A and 350 cfm in shop B of the plant.

   Assuming that the leak load could be reduced by 50% through a thorough inspection and repair program, the air savings would be 300 cfm. The AIRMaster+ model projects that this level of leak reduction would result in energy savings of about 183,700 kWh/yr with a corresponding cost savings of about $11,040/yr. The cost to repair the leaks is estimated at about $2,000 for material costs, resulting in a simple payback of about two months. It should be noted that these savings are likely conservative – the compressors are rated at about 19 kW per 100 cfm, so a savings of 300 cfm would likely be closer to about 490,000 kWh/yr or a total of about $29,400/yr.

2. Adjust Cascading Setpoints on Compressors - Wands (Near Term Opportunity)
An analysis of the pressure and power data for the shop B air compressors shows that when the air requirements are reduced, the compressors may be fighting each other resulting in excess compressor starting, stoping and energy consumption. The LogTool graph below shows a 1-1/2 hour period in the late afternoon of July 11, 2007 that illustrates this. Compressor 4 loads to meet the air requirements caused by the drop in system pressure, and this causes Compressor 3 (with the VFD) to unload. But as Compressor 4 reaches its unload pressure and the motor amps drop off, the drop in pressure then simply causes Compressor 3 to load up. At the time of the site visit, Compressor 4 was set to unload at 105 psi and load at 93 psi, with the setpoint pressure located at the compressor discharge. Compressor 3 was set to unload at 109 psi and load at 99 psi, making it the baseload compressor.



The AIRMaster+ model was adjusted so that Compressor 4 was chosen as the baseload compressor by setting the unload point at 109 psi and the load point at 97 psi, and the controls on Compressor 3 were adjusted to unload at 104 psi and load at 94 psi. The AIRMaster+ model projects that changing these cascade controls would result in energy savings of about 693,700 kWh/yr and cost savings of about $41,700/yr. Plant personnel will want to visit with their Ingersoll-Rand reps to make sure this change will not cause any detrimental effects to either compressor, but it should be simple enough to reset the control points on the compressors and monitor the compressors to assure the plant air requirements are met. It's also important to note that the pressure measured by the data logger shown above was measured close to Compressor 4 and the controls points may have to be adjusted because the compressors are located about 600 feet apart and likely do not see the same system pressure. Alternatively, an automatic sequencer would likely correct this issue, although the distance between compressors has been the reason this was not pursued in the past. A third option might be to install an automatic sequencer in the east compressor room so that the two 350 hp compressors could be used as the baseload and trim compressors and the unload/load points on the 250 hp compressor in the west compressor room could be set so that it becomes the third compressor online.

3. Improve End Use Efficiency – Eliminate Cabinet Coolers (Near Term Opportunity)
Plant personnel noted that compressed air is supplied to eight venturi cabinet coolers that cool electrical equipment cabinets in one area of the plant. These cabinet coolers typically use about 35 cfm of air continuously, although the consumption varies with the cooling capacity required. Plant personnel would like to replace the cabinet coolers with fans or other mechanical means that do not use compressed air. If all of the cabinet coolers were replaced, the air savings would be about 35 cfm × 8 = 280 cfm, a little more than the estimated leak load 250 cfm in that area. Allowing that each cabinet cooler could be replaced with an air conditioning unit that consumes 2.5 kW, the AIRMaster+ model projects that this reduction in consumption would result in energy savings of about 128,600 kWh/yr and cost savings of about $7,730/yr. The estimated cost for refrigerant cabinet coolers is $1,000 each for a total of $8,000, resulting in a simple payback period of about one year. It should also

noted that these type of venturi cabinet coolers are common and that they have the benefit of having no moving parts, very little maintenance, and allow no outside air into the cabinet to provide cooling. Plant personnel may also wish to consider a retrofit kit that contains a thermostat and a solenoid that limit compressed air to only when cooling is required.

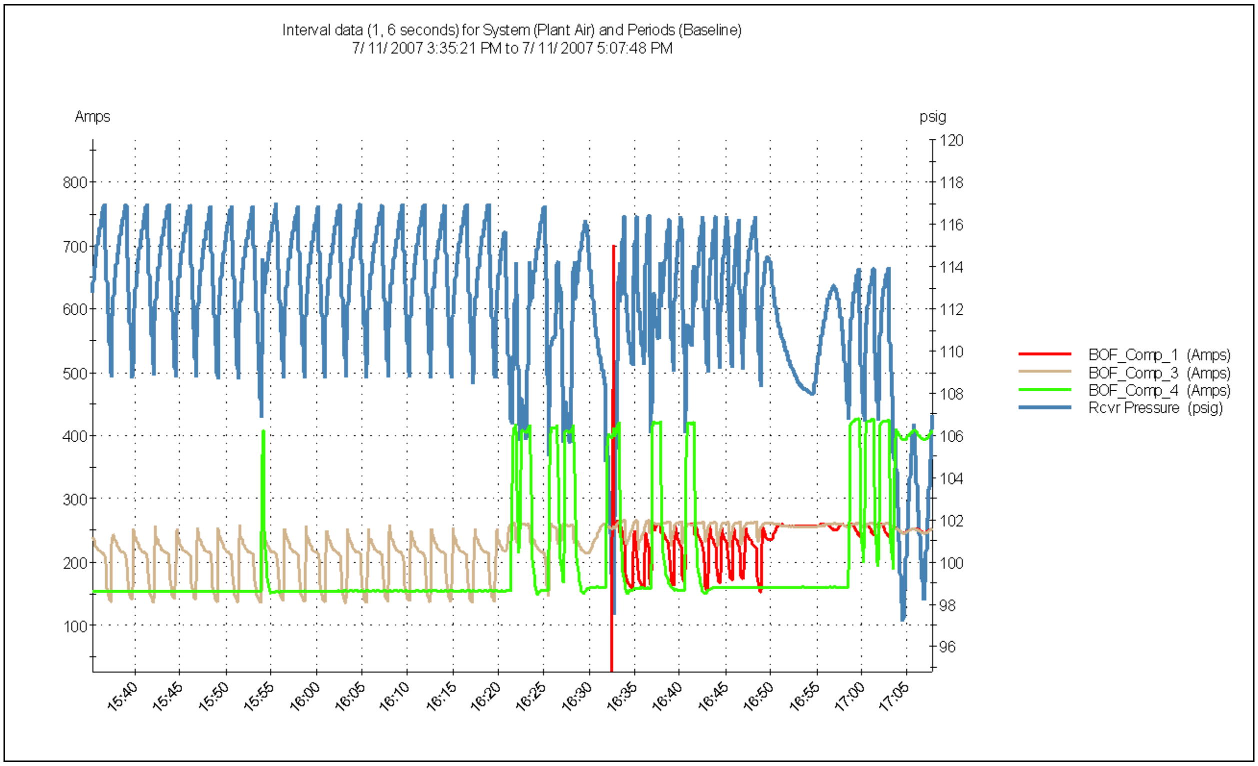
4. Improve End Use Efficiency – Shut Down Tower Air When Not Required (Near Term Opportunity)
   Plant personnel also noted that a cooling tower uses about 200 cfm when the tower is not being used and that this operation could be retrofitted with a solenoid valve to reduce the compressed air flow during these periods. However, given the often sporadic nature of the production schedule, it is difficult to estimate the time over which these savings would accrue. As a first approximation, the AIRMaster+ model was adjusted for a reduction of 200 cfm for 4 hours per day every day. This reduction in consumption would result in energy savings of about 36,200 kWh/yr and cost savings of about $2,170/yr. Allowing $2,000 for purchase and installation of an appropriate solenoid valve controller, the simple payback period is just under one year.

5. Improve End Use Efficiency – Eliminate Air Horns (Near Term Opportunity)
   Plant personnel noted that blowers have replaced venturi air horns that are used to cool down tundishes in the repair shop. These air horns, which were originally designed to evacuate flammable gasses from underground storage tanks, are large consumers of compressed air. Depending upon the supply pressure, the compressed air consumption ranges from 117 scfm at 50 psig supply to 197 scfm at 90 psig supply. This could be a fairly significant air consumer if misused, especially since the plant has had success with blowers to cool the tunnel furnace shell. Again, given the often sporadic nature of the production schedule, it is difficult to estimate the time over which these air horns are used and could be replaced with blowers. As a first approximation, the AIRMaster+ model was adjusted to consider a reduction of 152 cfm (the consumption of one air horn at 50 psig supply) for 4 hours per day every day. This reduction in consumption would result in energy savings of about 12,530 kWh/yr and cost savings of about $750/yr. Allowing $800 for purchase and installation of two blowers rated at 3,000 cfm each, the simple payback period is just over one year.

6. Improve End Use Efficiency – Use Engineered Nozzles Instead of Open Blowing (Near Term Opportunity)
   Plant personnel noted several locations where open air lines are used to provide cooling or wiping: at the entrance to the tunnel furnace and at the tunnel furnace exit for the pyrometer. Although these lines are regulated down with ball valves, the compressed air consumption can still be significant. Preliminary calculations indicate that even at a line pressure of 50 psig, an open air line under the conditions at this facility would still use about 50 cfm or about 11 hp. Engineered nozzles like the ones used in the misters on the caster sections could lower the air consumption, typically by about 80%. Given the often sporadic nature of the production schedule, it is difficult to estimate the time over which these open lines are used and could be replaced with engineered nozzles. As a first approximation, the AIRMaster+ model was adjusted to allow for a reduction of 50 cfm for 6 hours per day every day. This reduction in consumption would result in energy savings of about 6,200 kWh/yr and cost savings of about $370/yr. Allowing $200 for purchase and installation of two engineered nozzles, the simple payback period is about 6 months.

7. Improve End Use Efficiency – Install More Receiver Volume near Large Intermittent Loads (Medium Term Opportunity)
   An examination of the LogTool data for one use area indicated that although there is a sequencer for the three newest air compressors in the compressor room serving this area, there is still a fair amount of cycling on the trim compressor, as the graph below shows for a 1-1/2 hour period in the afternoon of July 11, 2007. Note how for much of this period when production air requirements are reduced, one compressor was required and was loading up about every two minutes.

   Locating additional or designated receiver volume near large intermittent loads allows the system to meet load requirements without drawing down the system pressure. The additional volume also conserves energy by lengthening the compressor cycle time so that complete blowdown is achieved and the full benefits of load/unload controls are realized.



A common rule of thumb is that there should be 5 - 10 gallons of storage capacity per cfm of trim compressor. For a compressor with a capacity of 1,733 cfm, this translates to about 8,700 to 17,300 gallons. The existing receivers total about 4,280 gallons and the storage in the lines is estimated to be another 2,720 gallons for a total of about 7,000 gallons (about 4 gallons per cfm). Adding another 4,500 gallons would increase this to about 6.6 gallons/cfm. As a first approximation, the AIRMaster+ model was adjusted to add an additional 4,500 gallons of storage, which modified the system airflow and power profiles to reflect operation with increased storage capacity. AIRMaster+ predicts that energy and cost savings of about 13,000 kWh/yr and $780/yr as a result of this additional storage. Using estimations from an Ingersoll-Rand proposal at this plant a few years ago, the cost of a 4,500 gallon receiver is estimated to be about $15,000, resulting in a simple payback of about 19 years. However, plant personnel noted during the ESA that there are several unused receivers that could be refurbished and certified for use as air receivers, which would lower the implementation costs significantly and may make this opportunity more attractive.

The energy savings from these opportunities total about 1,073,800 kWh/yr and $64,500/yr, as shown in the table below:

ENERGY EFFICIENCY MEASURES (EEMs) SUMMARY									
Description	EEM No.	Energy Savings *kWh/yr*	Energy Cost Savings *per year*	Compressed Air System Energy Savings	Demand Savings *kW-mo*	Demand Savings *per year*	Installed Cost	Total Savings *per year*	Simple Payback *years*
BOF									
Reduce Air Leaks	1	132,665	$7,974	4.4%	74.5	$0	$1,000	$7,974	0.1
Eliminate Cabinet Coolers	2	128,567	$7,728	4.3%	22.7	$0	$8,000	$7,728	1.0
Shut Down Tower Air When Not Required	3	36,164	$2,174	1.2%	0.0	$0	$2,000	$2,174	0.9
Add Primary Receiver Volume	4	13,024	$783	0.4%	0.0	$0	$15,000	$783	19.2
SUBTOTALS		**310,420**	**$18,659**	**10.3%**	**97.2**	**$0**	**$26,000**	**$18,659**	**1.4**
BOF									
Reduce Air Leaks	1	51,018	$3,067	1.7%	35.3	$0	$1,000	$3,067	0.3
Adjust Cascading Set Points	4	693,678	$41,697	22.5%	4.4	$0	$1,000	$41,697	0.0
Eliminate Air Horns - 4 h/day	2	12,530	$753	0.4%	0.0	$0	$800	$753	1.1
Use Engineered Nozzles - 6 h/day	3	6,183	$372	0.2%	0.0	$0	$200	$372	0.5
SUBTOTALS		**763,409**	**$45,889**	**24.8%**	**39.7**	**$0**	**$3,000**	**$45,889**	**0.1**
PLANT TOTALS		**1,073,829**	**$64,548**	**35.1%**	**136.9**	**$0**	**$29,000**	**$64,548**	**0.4**

About 99% of the identified electricity savings would result from Near Term Opportunities, with 1% from Medium Term Opportunities.

Definitions:

- Near term opportunities include actions that could be taken as improvements in operating practices, maintenance of equipment or relatively low cost actions or equipment purchases.
- Medium term opportunities would require purchase of additional equipment and/or changes in the system. It would be necessary to carryout further engineering and return on investment analysis.
- Long term opportunities would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.

Management Support and Comments:
Plant and corporate engineering personnel are pursuing energy efficiency, operating cost, and safety improvements throughout the site. Energy savings appears to be a priority at multiple levels of site and corporate management and engineering groups. Management and plant personnel were supportive of the ESA and the results derived from the training assessment. Plant staff will likely use AIRMaster+ and LogTool to assess energy saving opportunities at this plant and to benchmark the compressed air system performance.

DOE Contact at Plant/Company: (who DOE would contact for follow-up regarding progress in implementing ESA results…)

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